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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

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in its capacity as elected Office

Date of mailing (day/month/year) 05 November 1999 (05.11.99)	
International application No. PCT/JP99/00621	Applicant's or agent's file reference KW193
International filing date (day/month/year) 12 February 1999 (12.02.99)	Priority date (day/month/year) 19 February 1998 (19.02.98)
Applicant HIRAGA, Takayoshi et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

09 September 1999 (09.09.99)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Christelle Croci
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

整理番号 P06-970791 発送番号 101574

発送日 平成14年 4月 9日 1 / 2

拒絶理由通知書

特許出願の番号 平成10年 特許願 第052657号
起案日 平成14年 3月27日
特許庁審査官 吉川 潤 9651 5D00
特許出願人代理人 山崎 隆 様
適用条文 第29条第2項

この出願は、次の理由によって拒絶をすべきものである。これについて意見があれば、この通知書の発送の日から60日以内に意見書を提出して下さい。

理 由

この出願の下記の請求項に係る発明は、その出願前日本国内又は外国において頒布された下記の刊行物に記載された発明に基いて、その出願前にその発明の属する技術の分野における通常の知識を有する者が容易に発明をすることができたものであるから、特許法第29条第2項の規定により特許を受けることができない。

記 (引用文献等については引用文献等一覧参照)

- ・請求項1～5について、引用文献1～3
- ・備考

引用文献1, 2には、1個の真レーザー光源と、仮想レーザー光源を生成するように真レーザー光源からの光を回折する回折格子を用いた光ピックアップが記載されている。

ホログラムを用いて収差を補正することは、引用文献3に記載されている。

拒絶の理由が新たに発見された場合には拒絶の理由が通知される。

引 用 文 献 等 一 覧

1. 特開昭61-233445号公報
2. 特開昭59-58637号公報
3. 特開平4-132024号公報



発送番号 101574

2 / 2

先行技術文献調査結果の記録

- ・調査した分野：IPC第7版 G11B 7/12 - 7/14
- ・先行技術文献：特開昭60-173728号公報

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PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference KW193	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/JP99/00621	International filing date (day/month/year) 12/02/1999	Priority date (day/month/year) 19/02/1998
International Patent Classification (IPC) or national classification and IPC G11B7/14		
Applicant KABUSHIKI KAISHA KENWOOD et. al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 5 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 09/09/1999	Date of completion of this report 13.04.2000
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Poth, H Telephone No. +49 89 2399 2149 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/JP99/00621

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1-21 as originally filed

Claims, No.:

1-19 as originally filed

Drawings, sheets:

1/8-8/8 as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

- ☐ the entire international application.
- ☒ claims Nos. 5,17,18,19.

because:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/JP99/00621

- ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):
- ☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):
- ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
- ☒ no international search report has been established for the said claims Nos. 5,17,18,19.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1,2-4,6-16
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1,2-4,6-16
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1,2-4,6-16
	No:	Claims	

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/JP99/00621

As to "V. Reasoned statement ...":

1. Reference is made to the following document:

D1 = US-A-4720825

D3 = JP-A-6347689

D4 = JP-A-62234118

2. D1 already describes with figures 12 and 13 and col. 7 l.21-col.8 l.38 an optical pickup device comprising a single real laser light source 1, a member 52 for diffracting light emitted from said real laser light source 1 to form at least one imaginary laser light source, and a light spot forming optical element 6 for receiving light from said member 52 and forming a plurality of light spots 53, 54, 55 on tracks of a recording medium 7.
3. Thus, the subject-matter of claim 1 differs from what has been already described in D1 in that the diffracting member is a hologram member, wherein hologram patterns of said hologram member are determined so that diffraction light is given an inverse aberration of an aberration to be caused by optical elements in an optical path from said real laser light source to the recording medium.

As there is no more relevant prior art available than D1, the subject-matter of claim 1 is novel.

4. The problem underlying said features distinguishing the subject-matter of claim 1 from D1 has been, as expressed in said features, to inhibit aberration of the light spots on the tracks of the recording medium (cf. also p.3 1st and 2nd par. of the present application).
5. D3 already describes to form a diffraction hologram pattern in a way such that coma aberration is compensated (cf. in particular the last four lines of the abstract). However, this teaching relates to a single pattern which forms a plurality of light spots as e.g. in D1.

Thus, it may have been obvious to apply the technique of D3 in D1; but this would

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/JP99/00621

not have resulted in the provision of a plurality of hologram patterns for the plurality of light spots as presently claimed.

D4 suggests an additional hologram lens 12 for this object, what is not claimed in the present application.

Hence, the subject-matter has not been obvious, and, thus, involves an inventive step by virtue of Art.33(3).

6. Consequently, also the subject-matter of claims 2 to 4 and 6 to 16 being dependent on claim 1 involves an inventive step.

As to "VII. Certain defects ...":

1. Claim 1 has not been drafted in the two part form (cf. under "As to 'V. Reasoned statement ...'" no. 2 and 3, R.6.3(b)).
2. D1 is not mentioned and discussed in the description (R.5.1(a)(ii)).



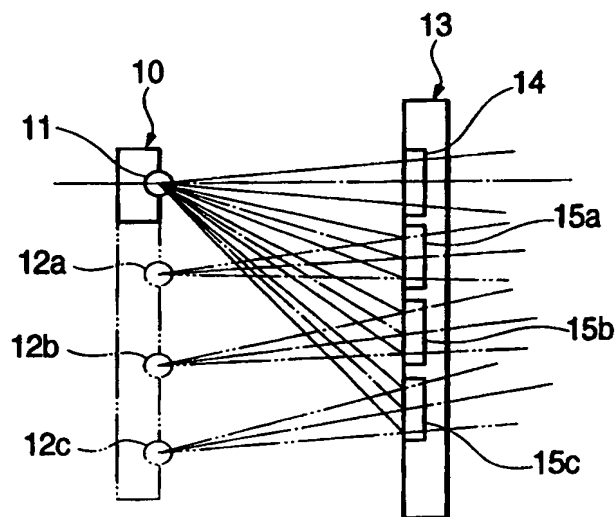
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/JP99/00621 (22) International Filing Date: 12 February 1999 (12.02.99) (30) Priority Data: 10/52657 19 February 1998 (19.02.98) JP (71) Applicant (for all designated States except US): KABUSHIKI KAISHA KENWOOD [JP/JP]; 14-6, Dougenzaka 1-chome, Shibuya-ku, Tokyo 150-0043 (JP). (72) Inventors; and (75) Inventors/Applicants (for US only): HIRAGA, Takayoshi [JP/JP]; 1-67, Takatori-cyo, Yokosuka-shi, Kanagawa 237-0067 (JP). MIYAZAWA, Hiroshi [JP/JP]; 20-7, Enoki-cyo, Tokorozawa-shi, Saitama 359-1104 (JP). SINZOU, Tohru [JP/JP]; Room 105, 652-2, Utuki-cyo, Hachioji-shi, Tokyo 192-0024 (JP). (74) Agent: KATO, Nobuaki; Fuji Building No. 602, 2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo 100-0005 (JP).		(81) Designated States: CN, KR, SG, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: OPTICAL PICKUP DEVICE USING HOLOGRAM PATTERN AND HOLOGRAM PATTERN GENERATING METHOD

(57) Abstract

Astigmatism and coma are suppressed in an optical pickup device of the type that light from a single real laser light source (11) is diffracted and divided by a hologram module (13) into a plurality of light spots which are focussed upon a plurality of tracks of an optical disk to read data on the tracks at the same time. A non-diffraction hologram pattern (14) and diffraction hologram patterns (15a, 15b, 15c) of the hologram module (13) are determined so that light diffracted by the hologram module is given inverse aberration of that to be caused by optical elements in an optical path from the real laser light source (11) to the optical disk. Another hologram pattern (14) provides a uniform intensity of a light spot formed of a laser light by an optical element.



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DESCRIPTION

OPTICAL PICKUP DEVICE USING HOLOGRAM PATTERN AND
HOLOGRAM PATTERN GENERATING METHOD

5 BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical pickup device for reading data from, and writing data into, a recording medium such as an optical disk and a card, and
10 more particularly to a multi-beam optical pickup device capable of forming light spots on a plurality of tracks of a recording medium at the same time.

2. Description of the Related Art

In one of the methods of reading at the same time data
15 recorded on a plurality of tracks of a recording medium such as an optical disk, light is emitted from an optical pickup device and focussed upon respective tracks of the recording medium, and light reflected from the tracks is detected with respective photodetectors. Methods of
20 forming a plurality of light spots as illustrated in Figs. 7 and 8 are known. Basics of these methods will be described with reference to Figs. 7 and 8 in which elements similar to those of the embodiments to be described later are represented by using identical reference numerals.
25 With the method illustrated in Fig. 7, a semiconductor

laser array 60 having semiconductor lasers same in number as the number of necessary light spots is used to emit light from light sources 61a, 61b, 61c, and 61d of the semiconductor lasers. With the method illustrated in Fig. 8, a single semiconductor laser 10 is used. Light emitted from a real laser light source 11 ("real" is used to distinguish from "imaginary" laser light sources 12a, 12b, and 12c to be later described) of the semiconductor laser 10 is divided by a diffraction grating 64 into a plurality of light fluxes which serve as those emitted from the light sources 61a, 61b, 61c, and 61d of the semiconductor laser array 60 shown in Fig. 7.

The method illustrated in Fig. 7 using the semiconductor array 60 is, however, associated with the following problems: (a) since a plurality of semiconductor lasers are assembled in one package or chip, there is a limit of reducing the size of the semiconductor laser array; (b) the number of connection terminals increases; (c) it is difficult to make the array compact because a surface area thereof is required to be as large as it allows heat dissipation; and (d) manufacture yield and cost are bad because it is necessary to use a plurality of semiconductor lasers having uniform characteristics.

Although only a single semiconductor laser can be used with the diffraction grating 64 and manufacture cost can be

lowered, it is necessary to mount the diffraction grating 64 at the position as near to the semiconductor laser as possible in order to make compact the optical pickup device. In this case, as shown in Fig. 9, the nearer to the semiconductor laser the diffraction grating is mounted, the larger the angle θ between the light beam incident upon the diffraction grating 64 from the real laser light source 11 and the diffraction light beam emitted from the diffraction grating 64 ($\theta_1 > \theta_2$). Therefore, astigmatism and coma of a light spot become large, which make the diameters of light spots 25a, 25b, and 25c larger and increase jitters in a reproduced signal.

SUMMARY OF THE INVENTION

It is an object of the present invention to solve the above-described problems associated with a conventional optical pickup device of the type that a plurality of light spots are formed by utilizing diffraction of light emitted from a single real laser light source.

An optical pickup device of this invention comprises:
(a) a single real laser light source; (b) a hologram member for diffracting light emitted from the real laser light source to form at least one imaginary laser light source; and (c) a light spot forming optical element for receiving light from the hologram member and forming a plurality of

light spots on tracks of a recording medium. In the optical pickup device, hologram patterns of the hologram member are determined so that diffraction light is given an inverse aberration of an aberration to be caused by optical elements in an optical path from the real laser light source to the recording medium.

The light spot forming optical element includes not only an optical element such as a lens having different thicknesses at the central and peripheral areas but also an optical element such as a Fresnel body of a plate type having a uniform thickness. The recording medium includes an optical disk as well as a card capable of data read/write. The aberration includes astigmatism and coma.

Tracks of a recording medium on which a plurality of light spots are formed may be discrete tracks or one continuous track. Namely, the track of the recording medium may be constituted of a plurality of concentric tracks or it may be a spiral one track.

The aberration caused by the optical elements in an optical path from the real laser light source to the recording medium may be the aberration caused by all or some of the optical elements. The hologram pattern of the hologram member is determined so that diffraction light is given an inverse aberration of an aberration to be caused by optical elements in an optical path from the real laser

light source to the recording medium. The hologram pattern is not always required to completely cancel out the aberration to be caused by the optical elements, but there is a case where the light spot suitable for data read has some aberration. In this case, the hologram pattern is designed so that a predetermined amount of intrinsic aberration is positively left without completely cancelling out, or a predetermined amount of aberration having an inverse sign of the intrinsic aberration is intentionally formed. Obviously, the effect of reducing an aberration of a light spot on a recording medium is greater for the hologram pattern of the hologram member which gives the diffraction light the inverse aberration to be caused by all the optical elements in the optical path from the real laser light source to the recording medium, than the hologram pattern which gives the inverse aberration to be caused by some of the optical elements.

The hologram pattern may be an amplitude hologram pattern with bright and dark interference fringes or a phase hologram pattern with binary (stepped cross section) or blazed (sawtooth cross section) grooves. The hologram member generates at least one imaginary laser light source. All of a plurality of imaginary laser light sources may be generated on one side or both sides of the real laser light source. Although the light spot formed on a track of a

recording medium is generally used for reading data on a track by detecting reflected light, it may be used for writing data.

The aberration to be caused by the optical elements in an optical path from the real laser light source to the recording medium is partially or completely cancelled out by the hologram pattern of the hologram member (although complete cancellation is preferable, partial cancellation is also applicable in practice). It is therefore possible to form a light spot on a track of a recording medium, which light source has reduced aberration or no aberration.

A column direction of hologram patterns of the hologram member of the optical pickup device of this invention is preferably aligned with the longer axis direction of the far field pattern of the real laser light source. The far field pattern is ellipsoidal and indicates a cross sectional intensity distribution of light fluxes at a position spaced apart by about 10 to 20 cm from a semiconductor laser emission point. A light spread angle is larger in the longer axis direction than in the shorter axis direction so that a light output having a more uniform intensity can be obtained in the longer axis direction than in the shorter axis direction. With the column direction of the hologram patterns aligned with the longer axis direction of the far field pattern, light can be applied at

a similar intensity both to the hologram pattern at the distal end of the hologram member and to the other hologram patterns. It is therefore possible to form imaginary laser light sources having a similar intensity to that of the
5 real laser light source, and to lower a difference between intensities of light applied to the hologram patterns. Since a plurality of light spots having a small intensity difference can be applied to an optical disk, it is possible to suppress a variation in data signals read from
10 the optical disk and photoelectrically converted. The quality of a data signal can therefore be prevented from being degraded. Since the hologram member is disposed, in a state capable of receiving light of a uniform intensity, at a position relatively remote from the real laser light
15 source, the angle θ described with reference to Fig. 9 can be made small so that astigmatism and coma of a light spot can be reduced.

The hologram member of the optical pickup device of this invention may be a phase hologram member. The
20 hologram pattern for diffraction light corresponding to each imaginary laser light source is determined so that an amount of diffraction light not forming a light spot is reduced and the reduced light amount is used as light spot forming diffraction light.

25 The diffraction light not forming a light spot has a

concept opposite to the light spot forming diffraction light. Of the diffraction light, the light propagating toward the light spot forming optical element becomes the light spot forming diffraction light, whereas of the light propagating outside of the light spot forming optical element becomes the diffraction light not forming a light spot. The phase hologram member can reduce the amount of light propagating in a specific direction and direct the reduced amount of light in a different direction. Therefore, a light spot having a high light intensity can be formed by reducing an amount of diffraction light not forming a light spot and using the reduced light amount as the light spot forming diffraction light.

In the optical pickup device of this invention, a light spot on a recording medium formed by non-diffraction light from the real laser light source is used for servo operations. The hologram member has a hologram pattern which provides a uniform light intensity of the serve light spot in a whole light spot area.

The servo operations are typically a tracking servo and include other operations such as a focus servo. A light spot on a recording medium formed by non-diffraction light from the real laser light source is used not only for dedicated servo operations but also for a combination with data read and the like, the latter being commonly used.

The servo light spot is required to have a small light intensity change even when it has a tracking shift or the like. However, a light spot on a recording medium has generally a light intensity high at the central spot area and low at the peripheral spot area. Such a light spot is not effective for the servo light spot. Light from the real laser light source corresponding to the servo light source passes through the hologram member without diffraction. If this light is passed through a hologram pattern which reduces the light intensity at the central spot area and provides a uniform light intensity of the light spot on a recording medium in a whole spot area, then a light spot suitable for servo operations can be formed.

An optical pickup device of this invention comprises:
(a) a single real laser light source; and (b) a light spot forming optical element for receiving light from the real laser light source via a hologram member and forming a servo light spot on a recording medium. The hologram member has a hologram pattern which provides a uniform intensity of the servo light spot in a whole servo light spot area.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing the configuration of an optical pickup device.

Fig. 2 is an enlarged view showing a portion of the optical pickup device shown in Fig. 1 from a semiconductor laser to a hologram module.

Fig. 3 is a schematic diagram showing a diffraction
5 hologram pattern.

Fig. 4 is a diagram illustrating a method of determining each diffraction hologram pattern using optical elements.

Fig. 5 is a diagram illustrating a method of forming
10 a plurality of light sources having characteristics coincident with the real light source, by using a pin hole member in place of half-mirrors shown in Fig. 4.

Figs. 6A to 6C are graphs and a diagram illustrating a method of improving tracking servo light spots.

Fig. 7 is a diagram showing the configuration of a
15 conventional optical pickup device which forms a plurality of light spots by using a semiconductor laser array.

Fig. 8 is a diagram showing the configuration of a
conventional optical pickup device which forms a plurality
20 of light spots by using a single semiconductor laser.

Fig. 9 is diagram showing an angle θ between the light beam incident upon a diffraction grating from a real light source and the diffraction light beam emitted from the diffraction grating disposed at a position spaced by some
25 distance from a semiconductor laser of the optical pickup

device shown in Fig. 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the invention will be described with
5 reference to the accompanying drawings.

Fig. 1 is a diagram showing the configuration of an optical pickup device 20, and Fig. 2 is an enlarged view of a portion of the optical pickup device 20 shown in Fig. 1 from a semiconductor laser 10 to a hologram module 13. The
10 optical pickup device 20 has an optical path in a range from the semiconductor laser 10 to an objective lens 19. The semiconductor laser 10 has a single laser chip. Light from a single real laser light source 11 ("real" is used to distinguish from "imaginary" laser light sources 12a, 12b,
15 and 12c) of the semiconductor laser 10 is radiated toward a hologram module 13. The hologram module 13 has one non-diffraction hologram pattern 14 and three diffraction hologram patterns 15a, 15b, and 15c. Light from the real laser light source 11 transmits through the non-diffraction
20 hologram pattern 14 without diffraction, and light from the real laser light source 11 is diffracted by the diffraction hologram patterns 15a, 15b, and 15c and advances toward a collimator lens 18. A diffraction light flux from each diffraction hologram pattern 15a, 15b, 15c is coincident
25 with a light flux radiated from a corresponding one of the

imaginary laser light sources 12a, 12b, and 12c. A column direction of the real and imaginary laser light sources 11, 12a, 12b, and 12c is parallel to a column direction of the non-diffraction and diffraction hologram patterns 14, 15a, 15b, and 15c. The real and imaginary laser light sources 11, 12a, 12b are disposed at an equal interval. In Fig. 1, although the non-diffraction and diffraction hologram patterns 14, 15a, 15b, and 15c are disposed on the hologram module 13 on the side of the semiconductor laser 10, they may be disposed on the hologram module on the opposite side of the semiconductor laser 10. Also in Fig. 1, although the non-diffraction and diffraction hologram patterns 14, 15a, 15b, and 15c are disposed separately in the column direction, they may be disposed partially overlapped in the column direction. Light emitted from the hologram module 13 passes through the collimator lens 18 to be transformed into parallel light fluxes which advance toward the objective lens 19. Light output from the objective lens 19 forms light spots 24, 25a, 25b, and 25c on respective tracks of an optical disk 23, as images of the real and imaginary laser light sources 11, 12a, 12b, and 12c. The tracks formed with the light spots 24, 25a, 25b, and 25c are sequentially positioned in a radial direction of the optical disk 23. Each reflected light spot of the light spots 24, 25a, 25b, and 25c propagates through the

objective lens 19 and collimator lens 18 in a direction opposite to the incoming light and reaches via a beam splitter (not shown) to a photodetector (not shown) to thereby read data on each track.

5 The real laser light source 11 is disposed so that the longer axis direction of its far field pattern becomes coincident with the column direction of the non-diffraction and diffraction hologram patterns 14, 15a, 15b, and 15c of the hologram module 13. The far field pattern of the real
10 laser light source 11 is ellipsoidal. The light intensity of the far field pattern maintains a predetermined value or higher in a longer span along the longer axis direction of the ellipsoid. Therefore, with the longer axis direction set as described above, the light intensity of the
15 imaginary laser light sources 12a, 12b, and 12c can be made uniform along the longer axis direction. The non-diffraction and diffraction hologram patterns 14, 15a, 15b, and 15c may be an amplitude hologram pattern with bright and dark interference fringes or a phase hologram pattern
20 with binary or blazed grooves formed on glass or the like.

Light from the real laser light source 11 receives astigmatism and coma because of diffraction at the hologram module 13 and deflection at the collimator lens 18 and
25 objective lens 19 so that the qualities of the optical

spots 25a, 25b, and 25c on the optical disk 23 are lowered. To avoid this, the diffraction hologram patterns 15a, 15b, and 15c are made so that outgoing light fluxes from these patterns are given inverse aberration of the total
5 astigmatism and coma in the optical path from the real laser light source 11 to the light spots 25a, 25b, and 25c. This inverse aberration is superposed upon the intrinsic total astigmatism and coma to thereby reduce or make zero the aberration of the optical spots 25a, 25b, and 25c
10 (although zero aberration is most preferable, reduction only may be applied practically). The inverse aberration may be an aberration of astigmatism and comma caused by diffraction only, which is the significant factor of aberration, instead of the inverse aberration of the total
15 astigmatism and coma in the optical path from the real laser light source 11 to the light spots 25a, 25b, and 25c. In this case, the astigmatism and coma of the optical spots 25a, 25b, and 25c are cancelled out partially with respect to the aberration caused by diffraction only.

20 Fig. 3 is a schematic diagram of each of the diffraction hologram patterns 15a, 15b, and 15c. A diffraction grating pattern 65 of the diffraction grating 64 of the conventional optical pickup device shown in Fig. 8 is a pattern constituted of a plurality of parallel
25 straight lines, because diffraction only is considered for

cancellation of total aberration. In contrast, each of the diffraction hologram patterns 15a, 15b, and 15c providing both the diffraction function and aberration cancellation function is a pattern constituted of curved lines in place
5 of parallel straight lines.

Methods of determining a hologram pattern will be described, which pattern gives, the diffraction light output from each of the diffraction hologram patterns 15a, 15b, and 15c, the inverse aberration of the total
10 aberration in the optical path from the real laser light source 11 to each of the light spots 25a, 25b, and 25c, in order to remove the astigmatism and coma of each of the light spots 25a, 25b, and 25c. With a first method, a hologram pattern is determined by placing a photosensitive
15 film on the hologram module 13 and recording interference fringes thereon by applying light from the real laser light source 11 and light sources placed at positions of the imaginary laser light sources, the light sources having the same wavelength as that of the real laser light source 11.
20 The hologram pattern determined by this method does not theoretically form aberration (astigmatism and coma) of diffraction. A second method uses computer analysis software. Such computer analysis software is already sold and known. For example, software "code V" of Optical
25 Research Associates in USA provides a formula (coefficients

of a polynomial) which calculates a hologram pattern for two light sources (in the above example, the real laser light source 11 and one of the imaginary light sources 12a, 12b, and 12c). A hologram pattern not theoretically forming aberration (astigmatism and coma) of diffraction is determined in accordance with the obtained polynomial. If aberration of the collimator lens 18 and objective lens 19 is to be taken into consideration by using this software, data of the collimator lens 18 and objective lens 19, such as radius of curvature, lens thickness, and aspherical coefficient, is entered to simulate the optical configuration of the optical pickup device. With this simulation, a formula is obtained which is representative of a hologram pattern to be formed on the hologram module 13 by light fluxes from the real laser light source 11 and light sources having no aberration and placed at positions of the light spots 25a, 25b, and 25c on the optical disk 23. A hologram pattern determined from this formula can remove both aberration of the collimator lens 18 and objective lens 19 and aberration of diffraction.

Fig. 4 is a schematic diagram illustrating a method of determining each of the diffraction hologram patterns 15a, 15b, and 15c by using optical elements. A half-mirror 35a is placed at an intermediate position of an optical path from the real laser light source 11 to the non-diffraction

hologram pattern 14, to partially reflect light downward. Half-mirrors 35b, 35c,... are also placed at intermediate positions of an optical path of the reflected light, to partially reflect light toward the diffraction hologram patterns 15a, 15b,... and transmit the residual light downward. The lowermost one (not shown) of the half-mirrors 35a, 35b, 35c,... is replaced by a full mirror to reflect light without transmit it downward. In this manner, a plurality of imaginary laser light sources 12a, 12b, and 12c having the characteristics coincident with the real laser light source 11 can be formed. Interference fringes to be formed at the position of the diffraction hologram pattern 15a by light fluxes from the real laser light source 11 and imaginary laser light source 12a are used as the diffraction hologram pattern 15a. For example, in order to record the diffraction hologram pattern 15a, photosensitive material is coated on the hologram module 13 and exposed with the interference fringe pattern. The diffraction hologram pattern thus obtained can cancel out and make zero the astigmatism and coma of diffraction.

Fig. 5 illustrates another method of forming a plurality of light sources having the characteristics coincident with those of the real laser light source, by using a pin hole member 50 in place of the half-mirrors 35a, 35b, and 35c shown in Fig. 4. Light emitted from the

real laser light source 11 is transformed by a collimator lens 47 into parallel light fluxes which are applied to the pin hole member 50 and output from pin holes 51a, 51b, 51c, and 51d. Light output from each pin hole is equivalent to the light output from the imaginary laser light source. By using light output from each pin hole, a diffraction hologram pattern of the hologram module 13 is determined.

Figs. 6A to 6C are graphs and a diagram illustrating a method of improving tracking servo light spots. Light transmitted through the non-diffraction hologram pattern 14 shown in Fig. 2 is used for reading data on a track of the optical disk as well as for tracking servo. A light spot 24 as a tracking servo light spot is required to have a uniform intensity over the whole area of the spot. However, as shown in Fig. 6A, the intensity distribution of light incident upon the non-diffraction hologram pattern 14 of the hologram module 13 from the real laser light source 11 has a mountain shape with an apex at its center. This intensity distribution can be improved by using a phase hologram pattern. Namely, the deeper the groove of a phase hologram pattern, the more the amount of non-diffraction light (0-th order light) can be reduced and the more the diffraction light amount can be increased by using the reduced amount of non-diffraction light as the diffraction light. Further, the more the width of a valley (groove) is

made equal to the width of a hill (non-groove), the more the amount of 0-th order light can be reduced and the more the diffraction light amount can be increased by using the reduced amount as the diffraction light. As shown in Fig. 5 6B, the depth of the groove 54 is made smaller at the position remoter from the optical axis center to thereby reduce the amount of 0-th order light and direct the reduced amount of light toward different directions. Instead of adjusting the depths of grooves 54, the depths of 10 grooves 54 may be made equal and the ratio of each non-groove width to a total width of each pair of adjacent groove 54 and non-groove is set as $a_1 > a_2 > a_3 > a_4 > a_5 > a_6 > \dots > a_n$, where $a_1, a_2, a_3, a_4, a_5, a_6, \dots, a_n$ are ratios at positions from a near position to the optical 15 axis center to a far position therefrom in this order. In the above manners, as shown in Fig. 6C, the light intensity distribution can be made uniform in some range about the optical axis center in a radial direction. By using the diffraction hologram pattern 14 having grooves 54 such as 20 shown in Fig. 6B, the intensity distribution of incident light can be made flat. If a tracking servo signal is generated from reflected light of a light spot formed by such uniform intensity light, this tracking servo signal is stable even if the objective lens is subject to a tracking 25 shift.

The imaginary laser light sources 12a, 12b, and 12c of the optical pickup device 20 shown in Figs. 1 and 2 are disposed on only one side of the real laser light source 11. Instead, they may be disposed on both sides of the real laser light source 11. In this case, the imaginary laser light sources 12a, 12b, and 12c are disposed on both sides of the real laser light source 11 generally in symmetry with the real laser light source 11. Further, although the non-diffraction and diffraction hologram patterns 14, 15a, 15b, and 15c of the optical pickup device 20 shown in Figs. 1 and 2 are disposed on the hologram module 13 only on the side of the semiconductor laser 10, they may be disposed on the hologram module 13 only on the side of the collimator lens 18, or on both sides of the hologram module 13 (diffraction hologram pattern 15a on the semiconductor laser 10 side, diffraction hologram pattern 15b on the collimator lens 18 side, and so on). Furthermore, although the diffraction hologram patterns 15a, 15b, and 15c of the hologram module 13 of the optical pickup 20 shown in Figs. 1 and 2 are disposed spaced apart in the column direction, they may be disposed partially overlapped in the column direction.

The optical pickup device of this invention has a hologram member which at least reduces aberration caused by optical elements in an optical path from the real laser

light source to a recording medium. Accordingly, it is possible to form a plurality of light spots on a recording medium, the light spots having a light intensity and shape suitable for data read/write of the recording medium.

5 The optical pickup device of this invention has a hologram member which provides a uniform intensity of a light spot which otherwise lowers its intensity from the central area toward the peripheral area. Accordingly, it is possible to form a light spot on a recording medium, the
10 light spot having a small change in the light intensity and being suitable for servo operations.

CLAIMS

1. An optical pickup device (20) comprising:
 - a single real laser light source (11);
 - a hologram member (13) for diffracting light emitted
 - 5 from said real laser light source (11) to form at least one imaginary laser light source; and
 - a light spot forming optical element (19) for receiving light from said hologram member (13) and forming a plurality of light spots (24, 25a-25c) on tracks of a
 - 10 recording medium (23),
 - wherein hologram patterns (15a-15c) of said hologram member (13) are determined so that diffraction light is given an inverse aberration of an aberration to be caused by optical elements (13, 18, 19) in an optical path from
 - 15 said real laser light source (11) to the recording medium (23).
2. An optical pickup device according to claim 1, wherein a column direction of the hologram patterns (15a-15c) of
- 20 said hologram member (13) is aligned with a longer axis direction of a far field pattern of said real laser light source (11).
3. An optical pickup device according to claim 1 or 2,
- 25 wherein said hologram member (13) is a phase hologram

member, and the hologram pattern (15a-15c) for diffraction corresponding to each imaginary laser light source (12a-12c) is determined so that an intensity of diffraction light not used for light spot formation is reduced and a reduced amount of light is used as diffraction light for light spot formation.

4. An optical pickup device according to any one of claim 1, wherein a light spot (24) on the recording medium (23) formed by non-diffraction light from said real laser light source (11) is used for servo operations, and said hologram member (13) has a hologram pattern (14) which provides a uniform intensity of the servo light spot (24) in a whole light spot area.

15

5. An optical pickup device comprising:

a single real laser light source (11); and

a light spot forming optical element (19) for receiving light from said real laser light source (11) via a hologram member (13) and forming a servo light spot on a recording medium (23),

20

wherein the hologram member (13) has a hologram pattern (14) which provides a uniform intensity of the servo light spot in a whole servo light spot area.

25

6. An optical pickup device according to claim 1, wherein the hologram pattern is an amplitude hologram pattern with bright and dark interference fringes or a phase hologram pattern with binary or blazed grooves.

5

7. An optical pickup device according to claim 1, wherein the hologram pattern is recorded on the hologram member on a side of said real laser light source.

8. An optical pickup device according to claim 1, wherein
10 the hologram pattern is recorded on the hologram pattern on an opposite side of said real laser light source.

9. An optical pickup device according to claim 1, wherein the hologram patterns are disposed at a predetermined
15 interval in a column direction of said real laser light source and the imaginary laser light source.

10. An optical pickup device according to claim 1, wherein the hologram patterns are disposed partially overlapped in
20 a column direction of said real laser light source and the imaginary laser light source.

11. An optical pickup device according to claim 3, wherein the hologram pattern for diffraction has curved patterns.

25

12. An optical pickup device according to claim 4, wherein the hologram pattern for diffraction has a plurality of grooves and an amount of light not to be diffracted is adjusted in accordance with depths of the grooves (54).

5

13. An optical pickup device according to claim 4, wherein the hologram pattern for diffraction has a plurality of grooves (54) and an amount of light not to be diffracted is adjusted in accordance with a ratio of a groove width to a non-groove width.

10

14. An optical pickup device according to claim 1, wherein said real laser light source is a semiconductor laser (10) having a single laser chip integrated therein.

15

15. An optical pickup device according to claim 1, wherein each of the hologram patterns gives the diffraction light a different aberration.

20 16. An optical pickup device according to claim 1, wherein each of the hologram patterns gives the diffraction light a same aberration.

17. A method of forming a plurality of imaginary laser
25 light sources (12a, 12b, 12c....) by forming diffraction

hologram patterns on a hologram member by using light from optical elements, the method comprising the steps of:

disposing a first optical element (35a) in an optical path from a real laser light source (11) to a non-diffraction hologram pattern (14), the first optical element partially reflecting downward light from the real laser light source;

disposing n (n is a positive integer) optical elements (35b, 35c...) in an optical path of the partially reflected light, the n optical elements partially reflecting the partially reflected light toward the hologram member and reflecting downward residual light; and

disposing an optical element for reflecting the residual light toward the hologram member.

15

18. A method according to claim 17, wherein the first and n optical elements are half-mirrors, and the optical element at said last step is a full mirror.

20 19. A method of forming a plurality of imaginary laser light sources (12a, 12b, 12c....) by forming diffraction hologram patterns on a hologram member by using light emitted from pin holes, the method comprising the steps of:

transforming light from a real laser light source (11) into parallel light by a collimator lens (47); and

25

disposing a member (50) having at least one pin hole (51a-51d) in an optical path of the parallel light.

FIG. 1

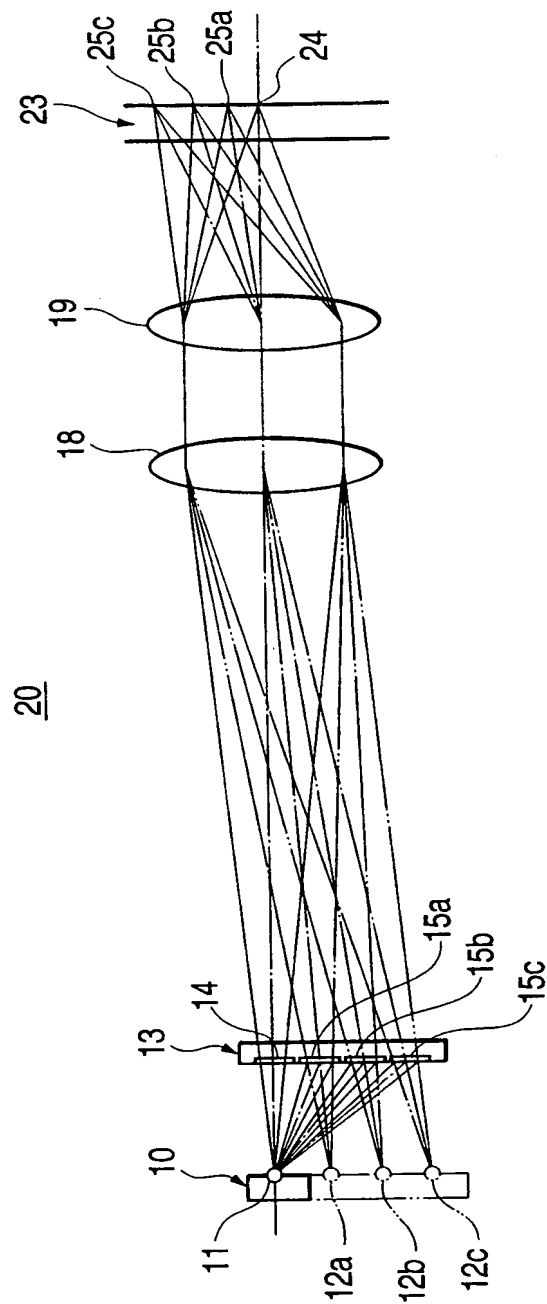


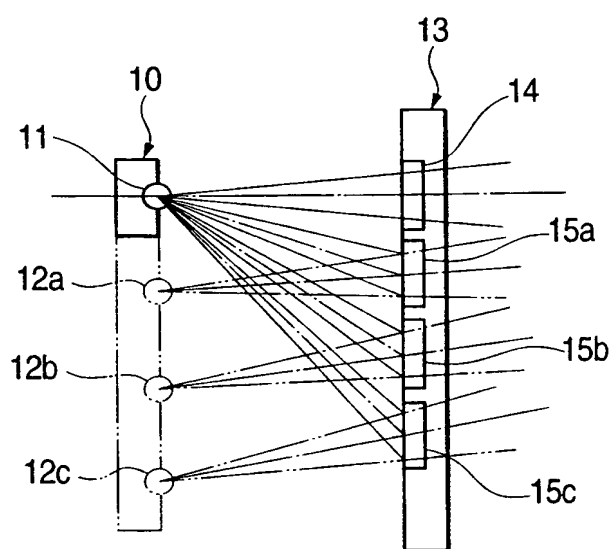
FIG. 2

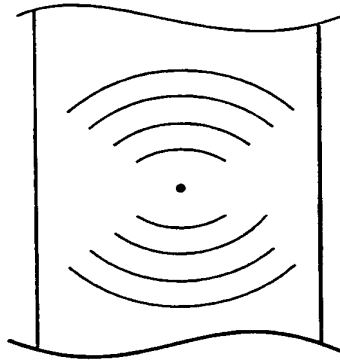
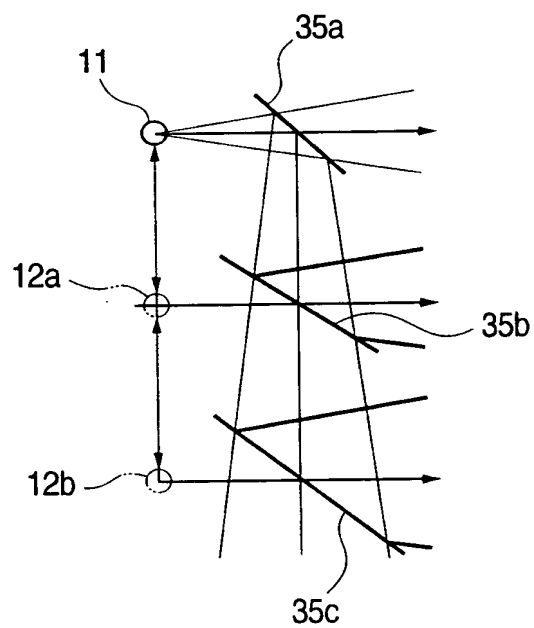
FIG. 3*FIG. 4*

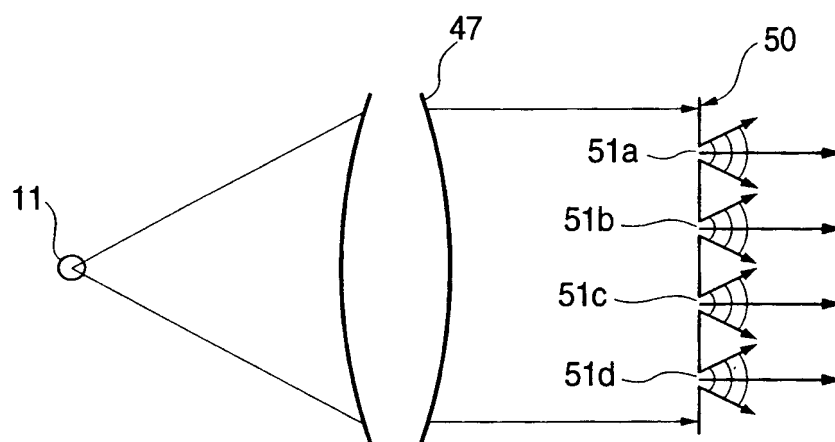
FIG. 5

FIG. 6A FIG. 6B FIG. 6C

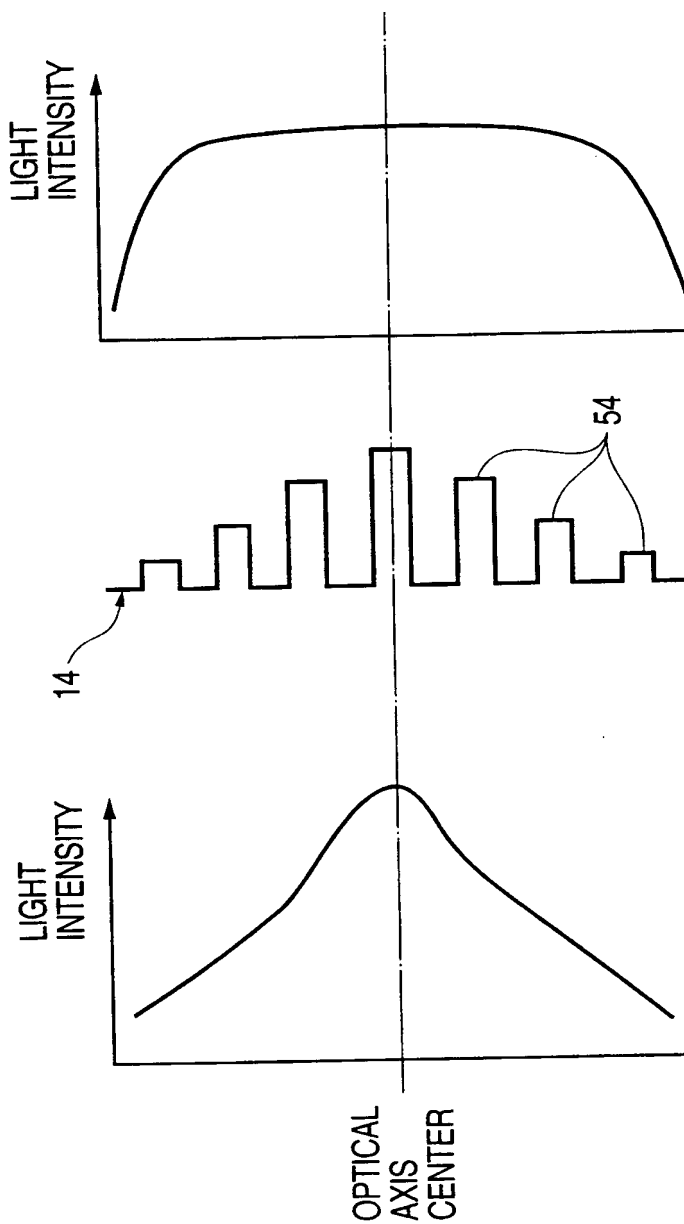


FIG. 7

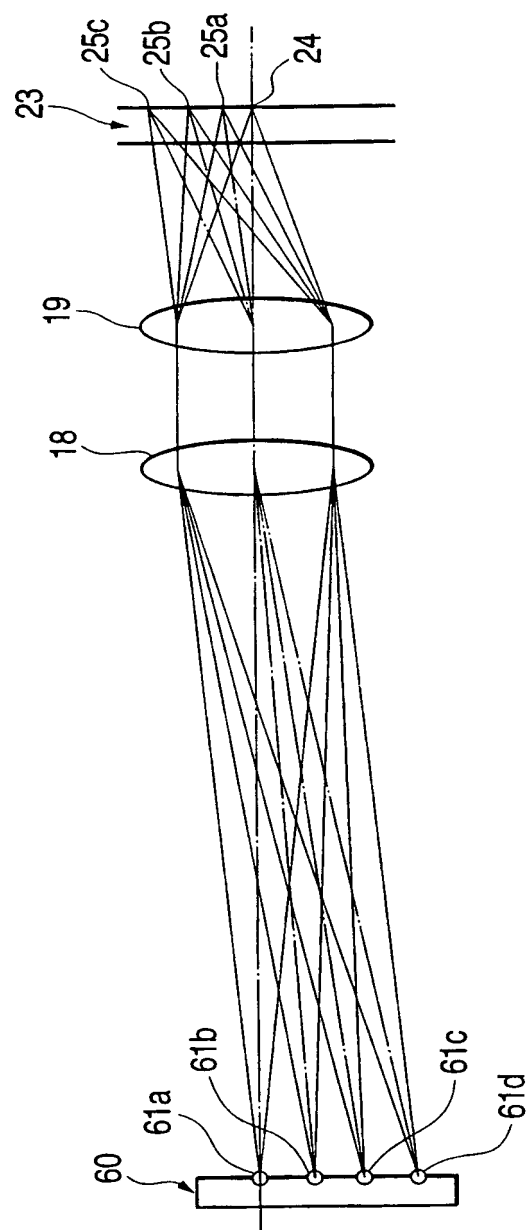


FIG. 8

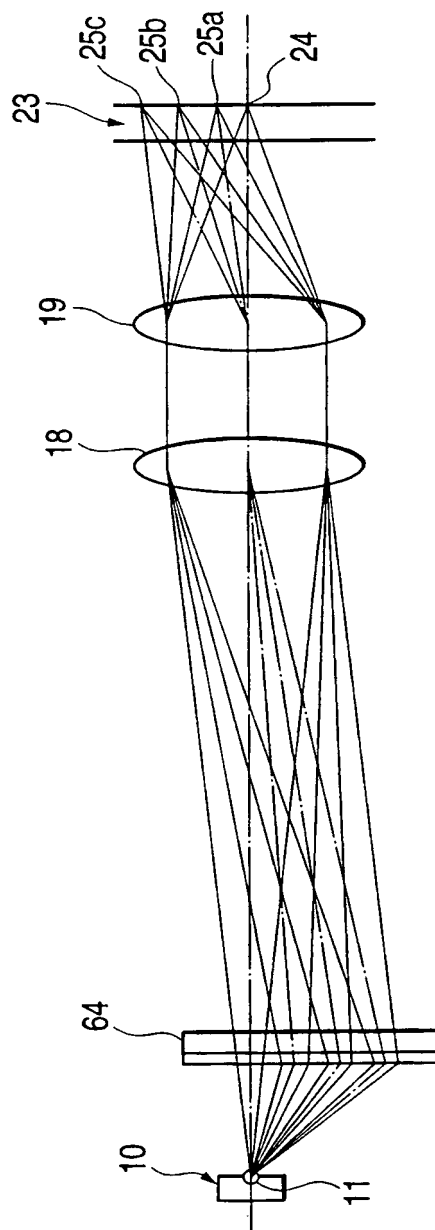
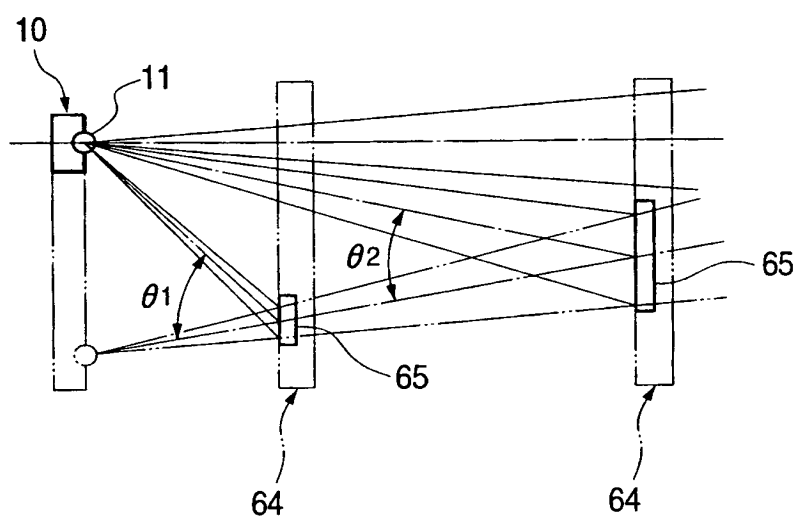


FIG. 9

INTERNATIONAL SEARCH REPORT

International Application No

PCT/JP 99/00621

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 G11B7/14 G11B7/135 G02B5/18 G02B5/32 G02B26/10
G01H1/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category ^o	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 720 825 A (KOKADO HIROSHI) 19 January 1988 see column 7, line 21 - column 8, line 31; figures 12,13 ---	1-4,6-16
A	US 4 787 075 A (MATSUOKA HIROSHI ET AL) 22 November 1988 see column 4, line 26 - line 40; figures 4,5 ---	1-4,6-16
A	PATENT ABSTRACTS OF JAPAN vol. 095, no. 003, 28 April 1995 & JP 06 347689 A (SEIKO EPSON CORP), 22 December 1994 see abstract --- -/-	1-4,6-16



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

^o Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

19 April 1999

Date of mailing of the international search report

19.07.99

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Poth, H

INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP 99/00621

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>PATENT ABSTRACTS OF JAPAN vol. 012, no. 102 (P-684), 5 April 1988 & JP 62 234118 A (FUJITSU LTD), 14 October 1987 see abstract</p> <p>-----</p>	1-4,6-16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP 99/00621

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-4, 6-16

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-4,6-16

"Aberration correcting hologram"

2. Claim : 5

"Uniform intensity generating hologram"

3. Claims: 17-19

"Plurality of holographic laser light sources"

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/JP 99/00621

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